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FUNCTIONAL WORKFLOW IN 3D CHARACTER DESIGN

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Abstract

The aim of this thesis is to design and create a 3D character suitable for use in a video game as well as to understand the entire process or workflow of 3D character creation, from its ideation through concept art to a game-ready 3D object.

While there are many ways to build a 3D character, certain workflows are more common amongst professionals. Limitations in computing power and processing speed of gaming devices are driving creative people to come up with more and more efficient ways of designing their game models. Research was done to find a current and functional workflow to design a 3D character.

The design process implements these findings to produce a fully-fledged 3D character, one that in theory could be used inside a game engine. An important learning outcome also includes a more thorough understanding of all the necessary phases in a 3D design workflow.

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Tiivistelmä

Opinnäytetyön tarkoitus oli suunnitella ja luoda 3D-hahmo videopelituotantoa varten, sekä myös ymmärtää kaikki 3D-hahmon luomiseen tarvittavat työvaiheet, aina ideoinnista ja hahmokonseptien luomisesta valmiiseen 3D-objektiin asti.

Vaikka 3D hahmon luomiseen on olemassa monia tapoja, ovat tietyt työtavat yleisempiä ammattilaisten keskuudessa. Tietokoneiden ja pelikonsolien prosessointinopeuksien rajoitteet ajavat luovien alojen ihmisiä keksimään yhä tehokkaampia tapoja suunnitella 3D-malleja peleihin. Tein taustatyötä löytääkseni toimivan ja nykyaikaisen tavan 3D-hahmon luomiseen.

Taustatietojen avulla loin 3D-hahmon, jota teoriassa voi käyttää pelimoottorin sisällä. Toinen tärkeä oppimistulos oli 3D-suunnittelussa käytettävien työvaiheiden syvempi ymmärtäminen.

Kieli
Englanti

Sivumäärä 28

Aihesanat
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1 INTRODUCTION

At its best, 3D can seem like a magic trick. Behind the scenes, it is somewhat a crude and a technical process, often mathematical and non-visual in nature. What is seen on the stage, however, is an illusion of a story, vibrant characters and usually an astounding visual experience.

Seeing *Frozen* for the umpteenth time and still being awestruck by the vivid character animations makes me want to have that ability to breathe life into my own digital creations.

The visual outcome of the thesis is a 3D character design. Through the design process I will dwell deeper into the world of 3D, clarifying concepts that I am already familiar with as well as learning entirely new tools applicable in 3D design. Aside from wanting to be a better visual storyteller, I also wish to understand and learn all the other areas in a 3D character design workflow. For this reason I am creating the character from its inception to its completion as a game-ready object.

The design process includes all the key phases of a 3D character development pipeline for a video game. From the initial sketching to rigging, all the phases are essential and nowadays used in professional 3D character development (Williamson 2011).

In a top-grossing company, employees usually have much more knowledge than that fitting to their job description. A concept artist, for example, most likely has a great working knowledge of a 3D package, whereas the senior 3D artist knows how to talk code with the programmers. The more each person understands what everyone else around them is doing, the more frictionless a project will be, and the more smoothly work will flow from one person to the next (Valve 2012). This naturally speeds up development and allows for bigger and better products to be created.

Consultations were made a few times during the design process to ensure that the theoretical understanding of the subject did indeed match the work. These open queries were done through a social media group and received answers from several individuals, many of them working professionals in game companies around Finland.

2 WHAT IS 3D?

> **You see 3D graphics literally everywhere these days, and at their core are digital models. Digital modelers work in television and feature films, game design, medical illustration and animation, print graphics, product and architectural visualization, and many other markets that make up this growing field. I've had my fingers in a lot of these markets over the years, and it has been interesting to see that I can use the same core skills for all of them. The subject matter and delivery method may change, but the fundamental toolset remains the same. (Vaughn 2012, 5.)**

3D graphics consist of a plethora of things, but digital models are often considered to be the core of the craft. Whether designing whacky characters for an animation film, creating fantasy environments for an online game, or working for BMW on their car commercial, it all comes down to the same fundamentals of digital modeling. (Vaughn 2012, 5.)

The field of 3D is booming with possibilities. It can seem bewildering at first just how many choices in software there are. A popular hub for digital artists, The CGSociety (2015) has several sub-forums for specific 3D programs, and while digital models can be created inside most of them, many of them have additional features such as digital sculpting, lighting, UV-mapping and rendering. Some programs are more specialized than others, and some offer a wider, more generalized toolset. Industrial designers and construction engineers tend to favor mathematically accurate representations, while a game artist's focus might simply be on what looks cool (game artists tend to cheat a lot to make things look good!). People have different approaches to problem solving, and different programs allow for different ways of problem solving.

Nowadays, 3D graphics are used for a great variety of things. The most obvious ones are Hollywood blockbusters, big budget video games and commercials. Many television series utilize 3D for otherwise hard-to-create elements such as set-extensions and visual effects. Short animation films by companies such as Pixar are used as proving grounds for rising artists, giving them experience to work on feature films. (Vaughn 2012, 344-350.)

With the increases in performance of tablets and phones, 3D is becoming more and more mainstream in the development of apps and games for mobile devices. The speed of prototyping inside a 3D program also makes it ideal for creative use in architectural and product design. In addition to fast prototyping, many finalized illustrations and visualizations are made almost entirely in 3D. The end result can range from stylized to photorealistic. (Vaughn 2012, 355-359.)

The Finnish sci-fi movie *Iron Sky* is a great example of the power of 3D. Created by a smaller independent company, they were able to produce amazing work while keeping production costs low. While it took a great deal of digital work to get the movie done, it allowed the movie makers to create from wherever they chose. (Vaughn 2012, 346-347.)

3 3D CHARACTER DESIGN

Characters, being the focal point in stories, require a lot envisioning, visioning and often some revision. As we spend so much of our time every day looking at fellow humans and their faces, even a person who knows nothing about 3D can see when the face of a 3D character is poorly made (Vaughn 2012, 213). The character models in animation and games also need to be able to perform a wide range of facial gestures as well as motions with their body. Because of this, models that deform (animate) must be created with utmost care. (Vaughn 2012, 239.)

3.1 Ideation & Sketching

> **“To model a character, I'd want to know the character's name, how old it was, where it was from, whether it was an introvert or an extrovert, and whether it prefers Ginger or Mary Ann (Vaughn 2012, 82).”**

We love stories. Storytelling is how our minds make sense of the world around us. We like to think up causes and effects even when there are not any (Kahneman 2012, 199). When we see a living being, we naturally ask ourselves questions. What is this thing? Where does it come from? Does it have good intentions or does it want to eat me? (Vaughn 2012, 81-82).

Even the most imaginative creation needs to be grounded in reality so that the audience can relate to it. To be able to create something that looks like it could be real, the artist must understand reality. If we want to create a bipedal humanoid character, understanding how the human body functions helps to add a great deal of believability to a creation. (Vaughn 2012, 80-81.)

Seeing a professional concept artist at work, conjuring up unimaginable things with a pencil, can seem like magic, but surely, it is not. Just like a professional basketball player moves through the field gracefully and shoot hoops with ease, a skilled artist will do the same after years of training their mind and hand to do exactly what they want. (Zhu 2012.)

Industry veteran Glen Southern uses 3D sculpting to bypass the 2D conceptual phase. The speed at which a 3D sculpture can be created these days makes it worthwhile to use it as a starting point in character design. (Vaughn 2012, 284.) But even a seasoned pro such as Glen starts his modeling by looking at and gathering real-world reference (Vaughn 2012, 301).

3.2 Modeling

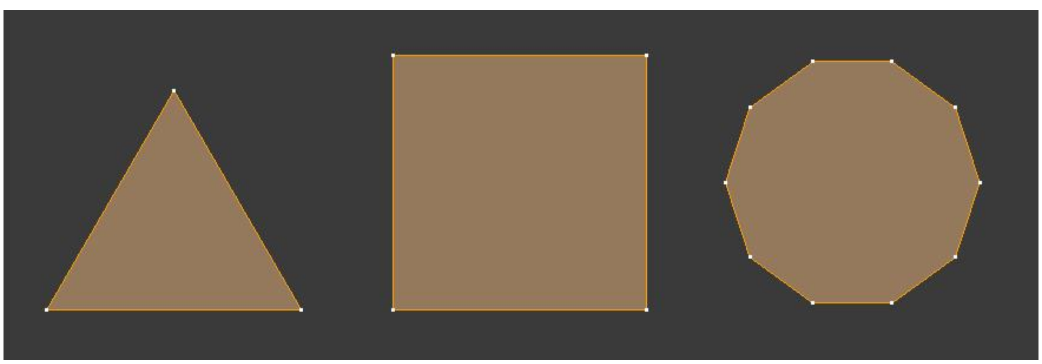
3D character modeling is mostly based on polygonal modeling methods. The other, less popular method is NURBS (Non-Uniform Rational B-Splines) modeling. NURBS is mainly used in computer-aided design (CAD), manufacturing and engineering, and not so much in character design (Vaughn 2012, 111). Since NURBS models are composed of curves, the surface of a NURBS object might break when deformed (animated). Polygon models will not break, and this makes polygons ideal for organic models such as characters. With polygon models, texturing is also more straightforward. (Kuhnen 2012.)

An important concept in polygonal modeling is SubDivision Surface (SubD). Each iteration of the SubD algorithm divides the polygons of a model by a factor of four, resulting in a smoother, more accurate representation of the desired form (Moyes 2008).

3.3 Anatomy & Topology in Modeling

Polygonal modeling functionality is the same regardless of the program being used. Popular 3D modeling applications such as 3DsMax, Maya, Modo and Blender all utilize the same fundamental principles when it comes to the structure of a polygonal model.

Picture 1 shows the basic components of polygonal modeling. A single point in 3D space is called a vertex. These vertices themselves have no dimensions or size. A line between two vertices is called an edge. Connecting three or more vertices with edges forms a polygon (commonly called a face). A continuous surface made out of polygons is referred to as a model or a mesh. Polygons that have three sides are called tris (short for triangles), and polygons that have four sides are called quads. Polygons that have more than four sides are called n-gons (n stands for the number of sides it has). (Vaughn 2012, 102-109.)



Picture 1. Vertices (white) make up edges (orange), which make up polygons (brown).

If the anatomy of a model is the what, then topology is the how. While all models are made of vertices, edges and polygons, the topological arrangements vary. Proper surface topology is of vital importance not just for modeling, but for numerous other stages in the development pipeline, as well (Vaughn 2012, 153-159).

To get the most out of subdivision surfaces, it is advised to have the mesh be composed of quads only. Triangles and n-gons often produce unwanted visual artifacts when they are rendered. Another thing to look for is poles. Poles are vertices with three, five, or more edges connected to them. Ideally, in an all-quad mesh, vertices would only ever have four edges connected to them. While it is impossible to avoid poles all together, their effect can be minimized by either placing them in areas not visible to the camera or by placing them in flat areas of the model. A completely flat surface will always render as such, regardless of the topology. (Petchkovski 2008.)

3.4 High-poly & Low-poly

3D models in next-generation video games often showcase a high level of surface detail. The task of rendering these game models in real time demands a lot of processing power, and if a scene has too many simultaneous objects to process, the frame rate can drop so much as to make the game unplayable. (Vaughn 2012, 149). A great way to take some weight off of the game engine is to keep the number of polygons in a game model to a minimum. The less polygons a model has, the less calculations it goes through at render time. This is why, in games, low-poly models are preferred. (Richardson 2008.)

However, with less geometry naturally comes less surface detail. The way we can have a low-poly model that looks like it has lots of surface detail is to cheat. A general practice in modeling for games is to first create a highly detailed (high-poly) model, and then copy the surface details on to a low-poly model. Two examples of low-poly yet high-detail characters can be seen in the work of character artist Nicolas Collings (Picture 2).

Picture 2. Low-poly game characters and their 3D meshes (Collings 2012).

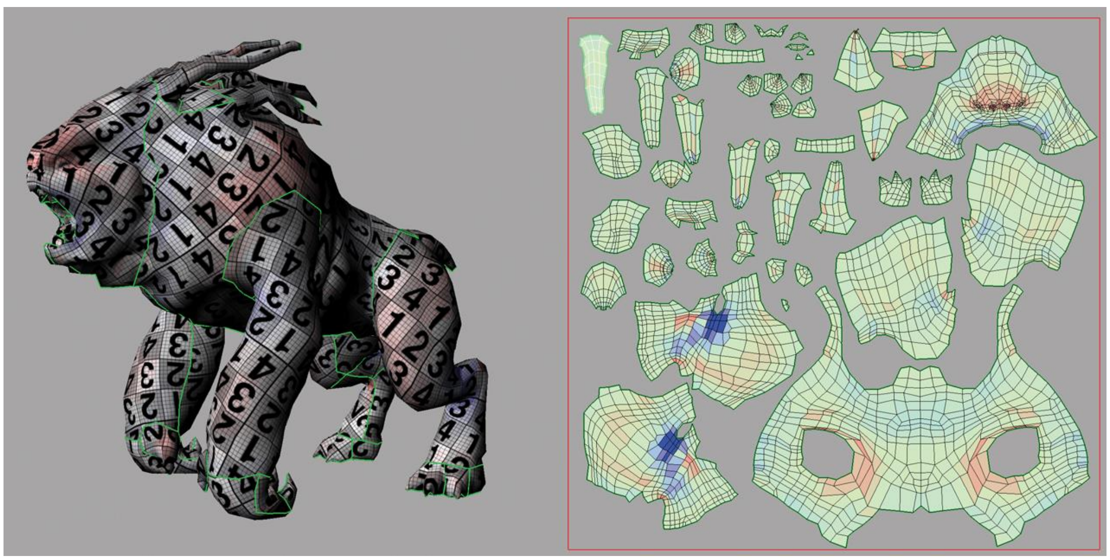
High-poly modeling is usually done using digital sculpting software like ZBrush. ZBrush essentially simulates the experience of real sculpting, yet is based on the same principles of pushing and pulling vertices around. After the high-poly model is finished, the model goes through a process called retopology. This means that the same model is created again, from scratch, but instead of millions of polygons, it would consist of only a few thousand polygons. (Puliero 2014.)

Copying the details from the high-poly model to the low-poly model is done via a normal map. A normal map is an image file that maps the X, Y, and Z coordinates of the surface normals[1] of an object to RGB (red, green and blue) values respectively. The process of creating a normal map is called baking. (Vaughn 2012, 318.)

[1] mathematical normal; a direction that is at a 90° angle to the surface

3.5 Maps & UV Coordinates

Before an image map such as a normal map can be successfully applied on the model, the 3D coordinates need to be transferred into 2D coordinates. This is done by unwrapping the model, that is, taking the surface and laying it flat in a UV space. The mesh can be split into sections to reduce any stretching of the polygons. (Vaughn 2012, 314.) Picture 3 shows what the result of a successful UV unwrapping might look like.



Picture 3. The surface of a model (left) laid flat on a UV map (right).

Once a UV map has been created, it can then be used to create all sorts of other maps. Color/diffuse maps simply add color to the surface of the model. Bump maps and normal maps create the illusion of added geometry, and a specular map can be used to create highly reflective areas such as metals or puddles. (Russel 2014.) An emissive map can even make the model emit light.

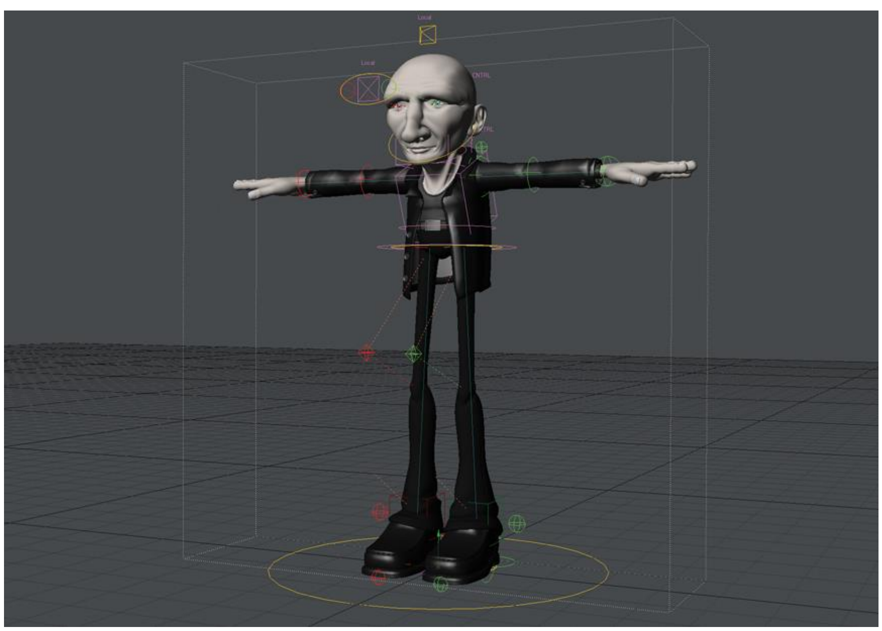
These days, with normal maps creating much of the details of the model, textures are not hand-painted as much. Before, texture artists would paint light and shadow information into the texture, but with the advent of normal maps, this has become largely unnecessary.

Which texture maps are used depends largely on the game engine. Different game engines show models differently. In a high-end game engine, it is possible to have a shader for each material (metal, leather, skin, etc.). (Phan 2014.)

3.6 Rigging

Until now, much of the focus has been on the surface of the character. Rigging literally adds the bones to a character and gives the animator the ability to do his/her thing. A rig, such as the one in Picture 4, gives the animator control over the body as well as the facial features of a character. (Vaughn 2012, 43.)

This is, again, where good topology comes to play. A bad mesh that that is not designed to deform can make the rigger's job impossible. Another area where the modeler can give a helping hand is to put the character in a good pose (usually a T-pose, with arms stretched on directly to the sides). Knowing what a rigger does helps the modeler help the entire project. (Vaughn 2012, 44-45.)



Picture 4. Controls of a character rig.

3.7 Animating

Animating the character model finally breathes much needed life into it. Using the rig created by the rigger, the animator uses his expertise to create believable motion, gestures and lip syncing. Running into problems is common at this point, as the animator may want to animate the character in a way unforeseen by both the rigger and the modeler. (Vaughn 2012, 52-53.)

Character animations in video games are interactive and depend on the player. Many animations, for example running, are created so that they loop seamlessly. A game character animator must consider all the simultaneous actions that the character may do, and also make sure that all those animations look good from multiple camera angles as well. (Landgraf 2012.)

Another kind of animator is the effects artist. He/she is responsible for all the non-model elements in a production, such as simulations of hair and fur, or elemental effects such as water, fire, smoke or dust. (Vaughn 2012, 55.)

3.8 Exporting

After all is said and done, a finished game character still needs to be exported into a game engine. Knowing a team’s file naming conventions and file types allows for a smooth transition of the character from the safety of a 3D program to the testing grounds of an actual game engine (Vaughn 2012, 142-143).

4 DESIGN PROCESS

My design process comes from several sources, each describing a fairly similar approach to 3D character design. While each game studio has their own methods and approaches, due to the requirements of their game, or to the constraints of time, budget and skill sets of the individuals, there exists a consensus on what the core phases in the process of 3D character design are.

While in the beginning this process is an attempt emulate this general, idealised workflow, the goal is, in the end, to understand the workflow so as to call it my own. Picture 5 shows my planned process for the character design. I eventually had to exclude the sculpting phase due to time constraints.

Picture 5. The design process plan.

4.1 Once upon a time…

I started by creating a setting, a world of my own. This world would have its own history, even on a cosmic scale. I painted a few conceptual paintings to illustrate (mostly to myself) how the primary planets would look and to further inspire me to think who would be living there. After I had some kind of a setting, I could think of what could happen there.

To create my character, I would have to first ask some questions. Where does she come from? What does she want? What is her role in the story? When story creation precedes character creation, it should make sense to the audience as to why these characters are enveloped in the story. Any character in a story should have a clear purpose, be it the hero who saves the day, a nemesis who poses a necessary challenge, or a supporting character who pronounces or undermines a feature in a main character.

My storyline centers on a girl named Zora. Shortly after she is born, a malevolent alien race conquers her planet, enslaving those who are able and slaying the weak. A good-willing elder named Katog chooses to take Zora to safety. In an attempt to escape, Zora and Katog end up in a distant and unknown part of the galaxy, crash landing their space ship on a strange cube-shaped planet. Katog must find a balance between preparing Zora for what's to come and allowing her to explore the world in her own terms.

4.2 Conceptualizing

Because a game is by nature an interactive experience, the most attention must be paid to how it feels to play the game. If, for example, a game is all about running and jumping, and if that running and jumping is not well made and does not feel exciting and rewarding in itself to the player, any further attempts at storytelling are in vain. If the controls become an obstacle to the player, fun will not be had.

The first thing that should happen in any game development is prototyping. The designers need to test their gameplay ideas, usually with little or no care for graphics, audio, or story. Once a solid gameplay is decided upon, everything else follows.

As my thesis is about 3D character design, the design process assumes a starting point where gameplay has already been decided upon, focusing mostly on how to achieve the aesthetic results that are to be expected in a video game of a big budget.

After writing the story, it became more obvious what the character needed in terms of looks, personality, and equipment. I started sketching the look of the body and face of this humanoid, visualizing what I think she should look like (Picture 6). Once I had something I was happy with, I took it over to Photoshop, where I tweaked the proportions and redrew some parts.

Picture 6. Sketches for the character (left) and weapon & equipment (right).

After settling for a body, I did numerous concepts on what direction I want to take the clothing, seen in Picture 7. I liked the general shape and flow of her body, so I wanted that to come through even with the clothing. I also wanted to stay away from portraying the character as overly sexy. Many female characters in video games these days are overly sexual, with their armors revealing much more skin than those of their male counterparts (Panepinto 2015). Picture 8 shows an initial concept illustration that was used as a guide in the modeling.

Picture 7. Clothing sketches in Photoshop.

Picture 8. I painted a concept art piece to help with the modeling.

I knew I wanted to have some equipment on her, both to add visual interest and to give the character some tools that could be used in the gameplay. In my head she was always a peace-loving wanderer rather than a warrior. After doing some weapon concepts, I ended up giving her a boomerang, which she could use for puzzle-solving or, if it came to that, stun her enemies to let her escape from harm's way.

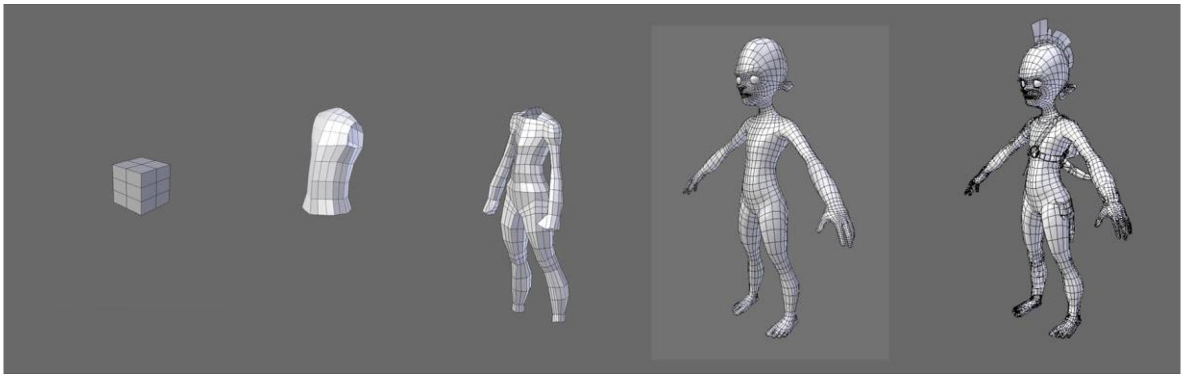
Even after a great deal of modeling I took screenshots of the model and brought them back to Photoshop to redesign some parts of the character. I found this back-and-forth between 3D and 2D to be helpful with finishing the character design.

4.3 Modeling

Like buildings, complex modeling benefits a lot from having blueprints. Inside a 3D program it is possible to have blueprints showing at all times when modeling. Preparing at least front and side projections (straight-on images without any perspective distortion) of objects beforehand can save time and nerves. I ended up creating front and right views as well as a back view, since my character had a lot of detail going on in the back (Picture 9).

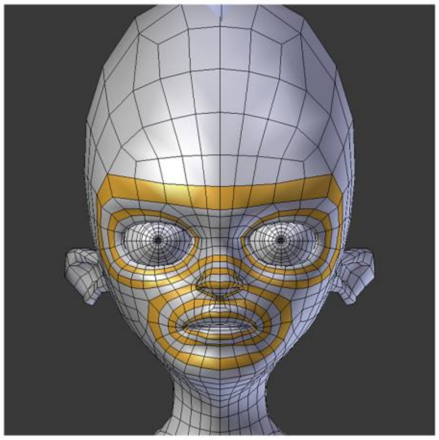
The entire character was created inside Blender, using a method called box-modelling (Picture 10). In this method, one starts with a box (or cube) for the torso, adding the arms and legs by extruding from that initial cube. Further refinement to the form was done by adding edge loops (a row of edges that goes around the form) where needed, and using the transform tools (move, scale, rotate) to tweak the faces, edges and vertices of the model in place.

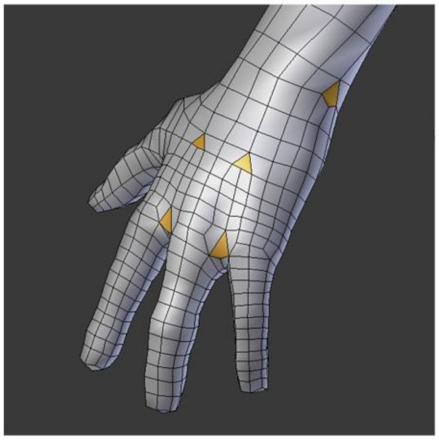
Picture 9. Final projection drawings.



Picture 10. The box modelling method was used to model the character.

I did a lot of research to achieve a good surface topology for my model. Proper surface topology, Vaughn (2012) writes, is important for animation because it makes surface deformations (such as the wrinkle of the cheek when smiling) look a lot better. Picture 11 shows how I used edge loops to create proper surface topology for the face area, as well as the hand in which triangle-shaped quads were used to increase the number of polygons.





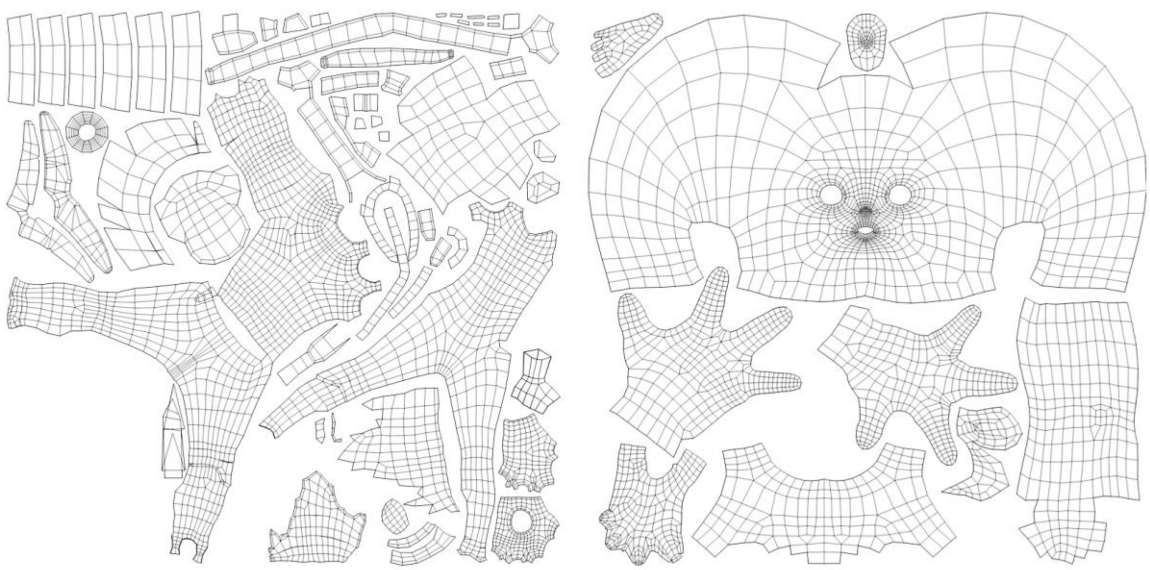
Picture 11. Surface topology.

Initially I wanted to bake a normal map to add more detail into my character. This would have meant creating a much more detailed model via sculpting either in Blender, or in Mudbox, and then transferring those details back into my low-poly model. I eventually decided I would not do this stage due to time constraints.

4.4 Texturing

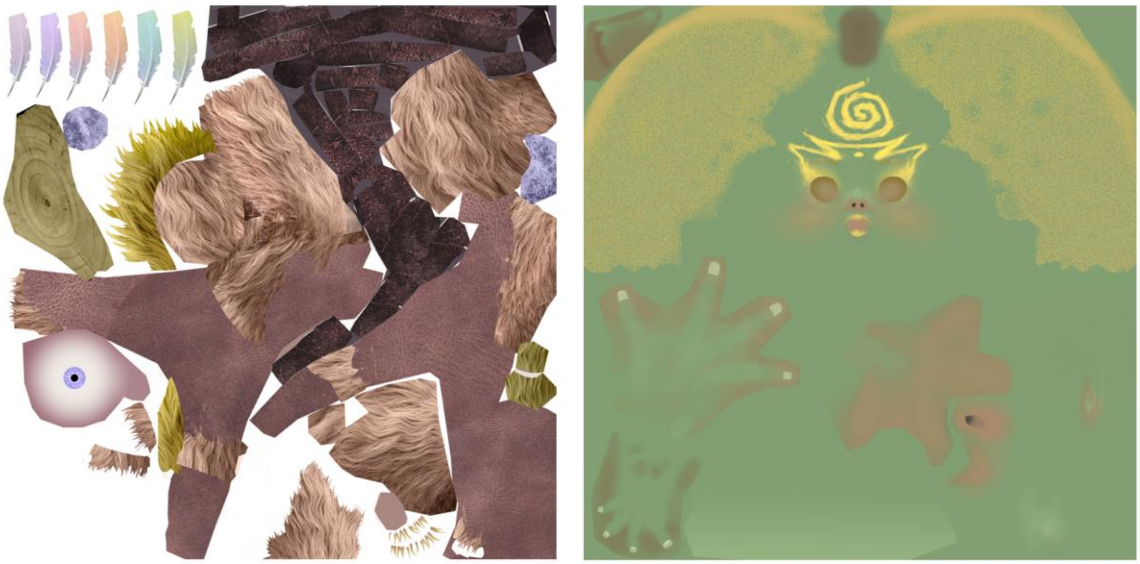
Skinning, or unwrapping the UVs of a model can be a royal pain. Think of it as reverse engineering a piece of clothing. Where to cut so that the pieces lay nicely flat with the least amount of stretching? This phase, I noticed, takes quite a lot of spatial thinking, and even when it seems to be right, the program might give surprising results if the wrong unwrapping mode is chosen (there are nine different modes in Blender).

Picture 12 shows two separate UV maps, the one on the right for skin areas and the one on the left for everything else. Picture 12 shows color textures that were painted using the UV maps as guidelines. The color maps were created in Photoshop, and many of them use a photograph as a base (Vijfwinkel & Starak 2015)



Picture 12. UV map of the equipment (left) and skin (right).

After unwrapping everything in my model, I started the texturing. This phase is like a coloring book, where one just colors inside the lines. It is, however, always a bit of a surprise to see 2D texture on a 3D model. It took some trial and error to figure out what works and what does not. I found many potentially good photo textures online, only to realize they just look wrong when seen on the model.



Picture 13. Texture images of the equipment (left) and skin (right).

4.5 Rigging and Posing

Of all the new things I have learned in this project, rigging was the easiest and most straight forward phase. After creating the rig (basically, bones of the character), I connected the bones to different parts of the model. This is called skinning, and it happens by painting different weights for different bones. Weights are painted using a gradient of colors from blue (no weight), to green (some weight), yellow (medium weight), and orange (much weight) to red (full weight). These weights have varying areas of influence, sections of the mesh that the different bones deform (either by rotating, moving or scaling). Picture 14 shows the weights of the head bone, seen as red. This bone is used to pivot the head around.

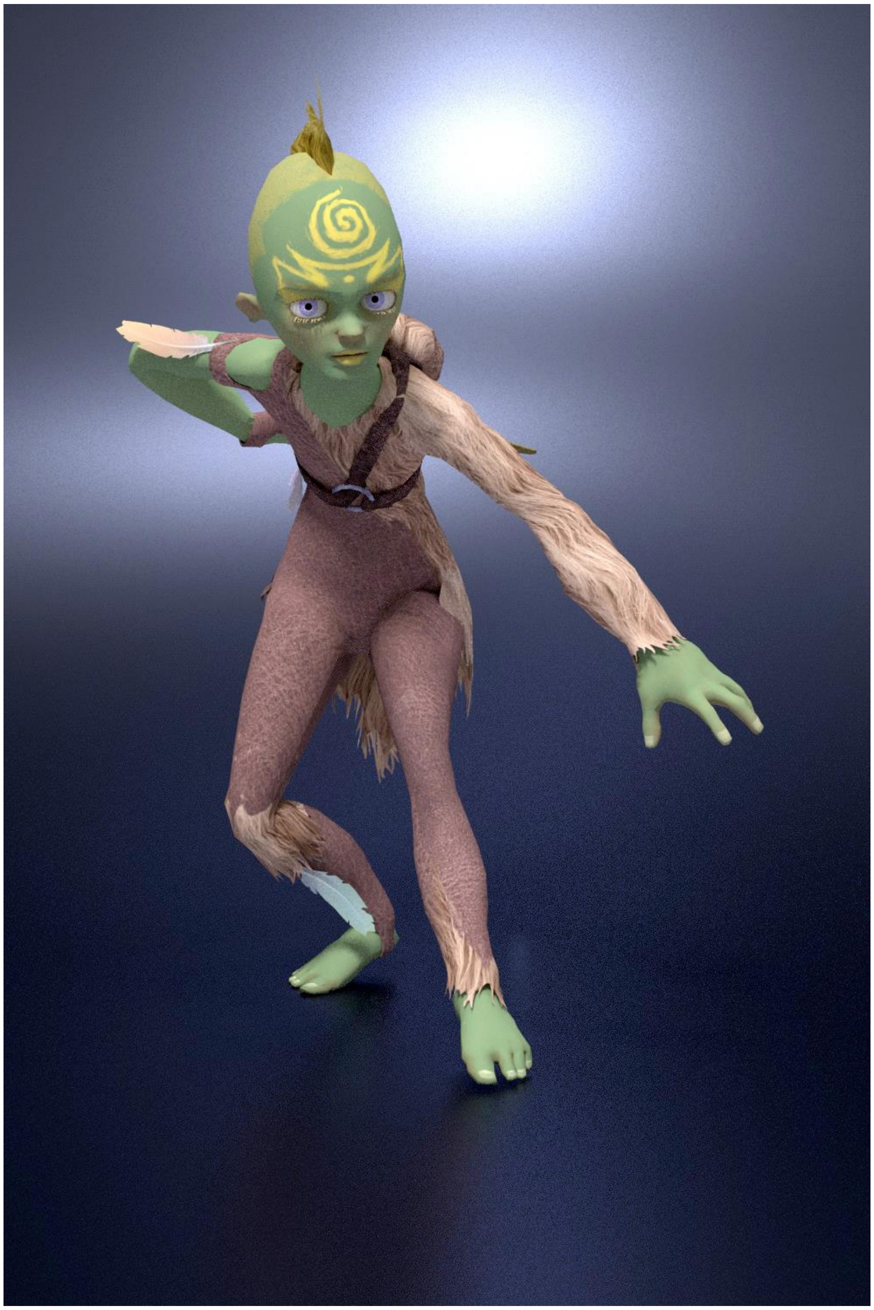
As I was posing the character, I had to keep going back to fix my rig and my weight painting. Joints that only pivoted in one axis, like the fingers, generally worked well. Ball joints, such as the hip joint, required more trial and error to get exactly right.

Picture 14. The rig on the left and the full effect of the head bone on a part of the mesh on the right.

4.6 Results

Video games are in constant motion, so even a very basic pose of a character usually has some movement built into it, for example the chest rising and falling as the character draws breath, or slight head turns to show that the character is looking around. For presentation purposes I created a static pose (as seen in pictures 15 and 16) that would tell a little more about the personality of the character.

Picture 15. Turnaround of the character.



Picture 16. A render of the final character inside Blender's Cycles Render engine.

5 CONCLUSION

I started this project knowing that it was a big one. I came out of it knowing it was even bigger. I learned a lot about what works and what does not, both in the 3D program and in myself. I have much appreciation for character artists, especially those with technical savvy. Even a visually simple game character can have a lot going on under the surface.

Looking back at the whole process, I feel that the character lost some of its visual flair somewhere along the line while being translated from a 2D sketch to a 3D character. Style-wise I felt that I downplayed some parts of the character too much.

Coming up with my own design and then seeing it come alive through animation is something that excites me to do more and better. I definitely want to venture into the world of sculpting and integrate that into my character design workflow. Seeing that I am able to create a 3D character makes me want to participate in community events and contests where works are judged and critiqued by professionals Moreover, having gone through all the steps and learning how each phase in 3D character creation ties together with the next makes me feel like I have a lot to offer in a game company.

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